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## Engineering Research Report

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**U.H.F. RELAY STATIONS:  
distribution transformers for use with  
the standard horizontally-polarised RBL aerial**

**No. 1972/16**



RESEARCH DEPARTMENT

**UHF RELAY STATIONS: DISTRIBUTION TRANSFORMERS FOR USE WITH  
THE STANDARD HORIZONTALLY-POLARISED RBL AERIAL**

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A handwritten signature in black ink, appearing to read 'P. Lang', is positioned above the title 'Head of Research Department'.

Head of Research Department

G.H. Millard, B.Sc., M.Inst.P.

(RA-99)



**UHF RELAY STATIONS: DISTRIBUTION TRANSFORMERS FOR USE WITH  
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## UHF RELAY STATIONS: DISTRIBUTION TRANSFORMERS FOR USE WITH THE STANDARD HORIZONTALLY-POLARISED RBL AERIAL

### Summary

*The design and performance are given of two printed circuit distribution transformers for use with the standard horizontally-polarised re-broadcast link (RBL) trough aerial.*

### 1. Introduction

The original design of RBL aerial employed a coaxial distribution transformer.<sup>1</sup> This design was changed by the manufacturing contractor to one using printed-circuit boards. The first design to be described, a four-way transformer, is an alternative to the contractors' design, so that the supply of trough aerials need not be confined to one manufacturer.

At the high-power relay stations it is normal practice to install two RBL aerials in order to give reserve facilities. However, the wind loading of these aerials is fairly high so that it is desirable for the low-power relay stations, which use a lighter-type of support tower, to use only one aerial. If reserve facilities are to be maintained it becomes necessary to feed the aerial in separate halves using the arrangement shown in Fig. 1. The second design to be described is a two-way transformer for this purpose.

Although the transformers were designed for use with a receiving aerial, the description of their behaviour is simpler if it is assumed that the system is transmitting and this practice will be adopted in this report. The principle of reciprocity states that an aerial system comprising linear, passive elements has identically the same directivity pattern for transmission and reception.

### 2. The four-way transformer

The highest impedance of the printed transmission lines was arbitrarily restricted to 100 ohms in order to avoid excessively narrow sections. Thus the sections immediately adjacent to the four inputs were chosen to have impedance of 100 ohms, 50 ohms, 50 ohms and 100 ohms in order to give the required current ratios. The remainder of the transformer was designed on the double-quarter-wave principle to give a source impedance of 50 ohms.

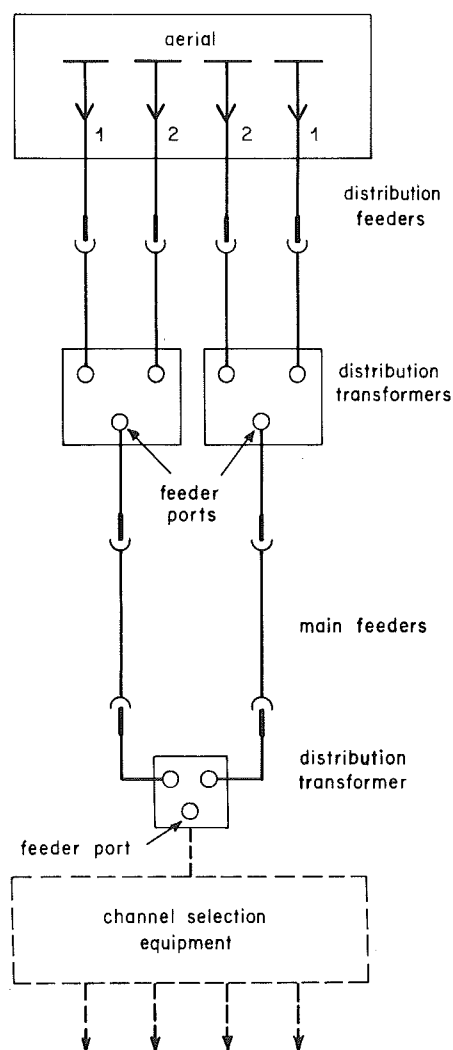


Fig. 1 - Receiving aerial feed arrangements at low-power UHF relay stations

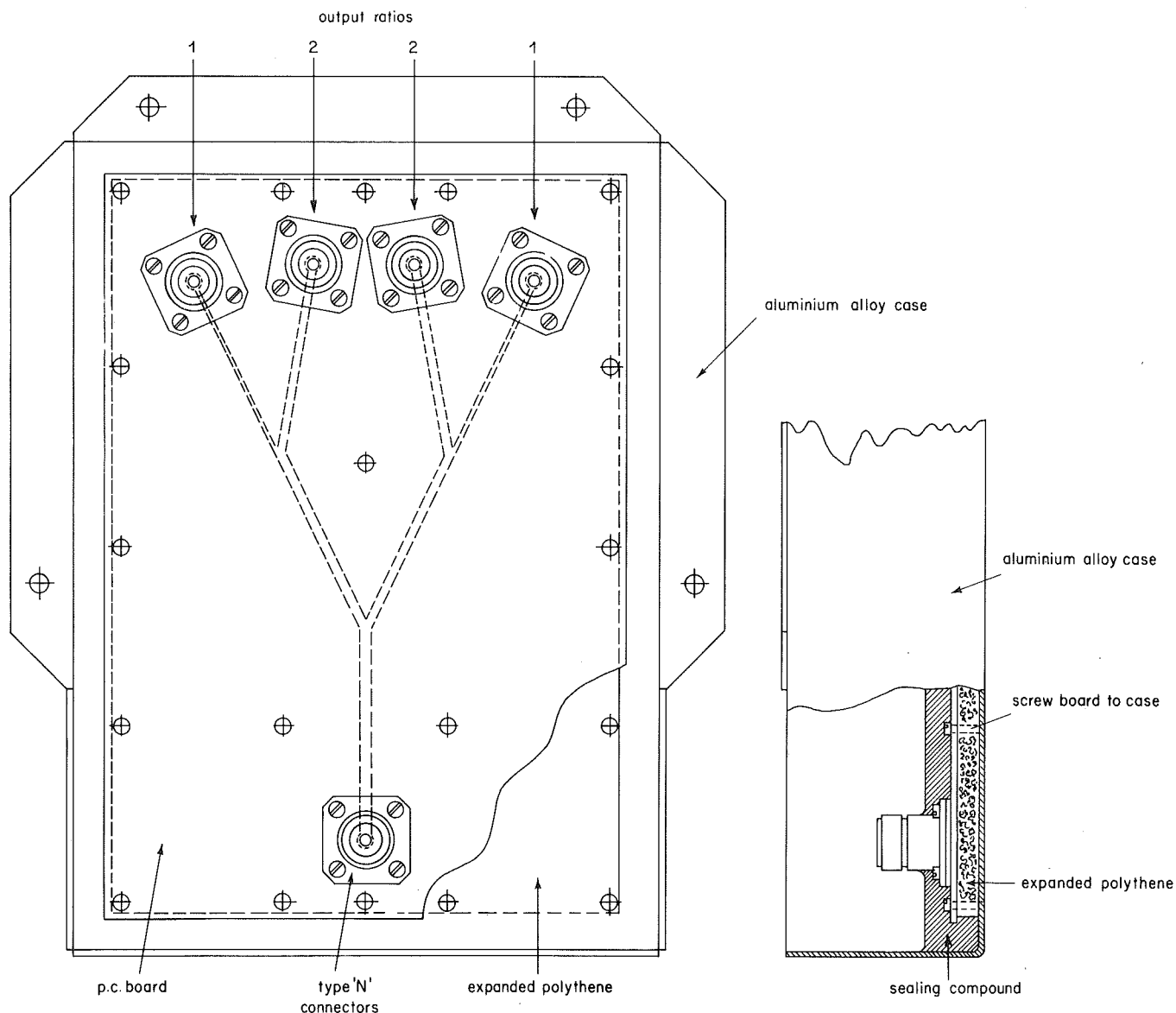


Fig. 2 - Layout of four-way transformer

The general arrangement of the transformer is shown in Fig. 2. MG51 laminate, copper clad on both sides, is used with one side carrying the strip lines and the other providing the ground plane. The printed circuit board is mounted in an aluminium alloy tray and sealed with a flexible potting compound.

The return loss of the transformer when terminated with the aerial elements is specified to be not less than 17 dB, corresponding to a voltage reflection coefficient of 14%. The reflection coefficient of the transformer alone should therefore be appreciably less than this. Fig. 3 shows that the reflection coefficient does not exceed 6% over the whole UHF band.

Fig. 4 gives the variation of current ratio with frequency. As there is some departure from the nominal ratio of 1 : 2 : 2 : 1, it is of interest to examine the effect of the ratio on the h.r.p. Fig. 5 shows the side-lobe levels obtained

with various current ratios and it will be seen that the side-lobe levels are less than those normally assumed provided that the ratio lies in the range 1.75 – 2.0. In the lowest part of the frequency range the ratio falls to 1.5 giving one side-lobe which is 3.5 dB greater than that usually assumed; it was thought that this did not justify producing a separate design for Band IV, as was originally intended, since a pair of the two-way transformers could be used if any particular difficulty should arise.

The dissipative loss in the transformer is 0.3 dB.

### 3. The two-way transformer

This was designed to give optimum performance with three line sections.<sup>2</sup> The layout of the printed-circuit board and the assembly, shown in Fig. 6, are basically similar to those of the four-way transformer. Two versions

of the design were produced to cover Bands IV and V respectively. Figs. 7 and 8 show respectively the variation with frequency of the reflection coefficient and the current ratio.

The horizontal radiation pattern of one half of a standard RBL trough aerial fed by the two-way transformer (i.e. the h.r.p. under emergency conditions) is shown in Fig. 9.

The dissipative loss in the transformer is 0.2 dB.

#### 4. Conclusions

Two designs of printed circuit distribution transformer have been produced for use with the standard RBL aerial. The availability of these designs will help to keep down costs of relay stations and will increase the flexibility of the RBL aerials.

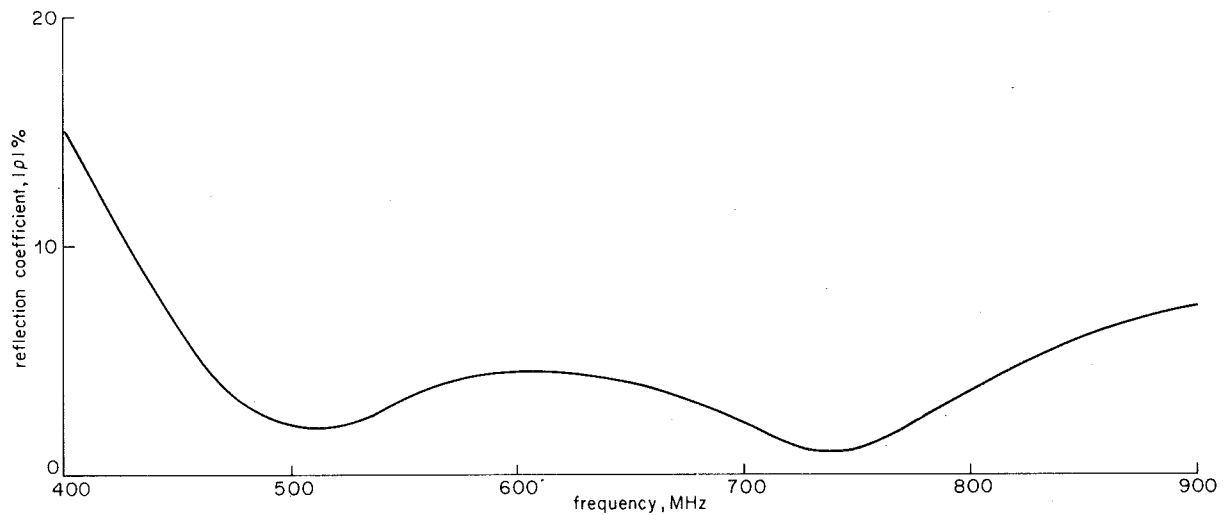


Fig. 3 - Reflection coefficient of four-way transformer

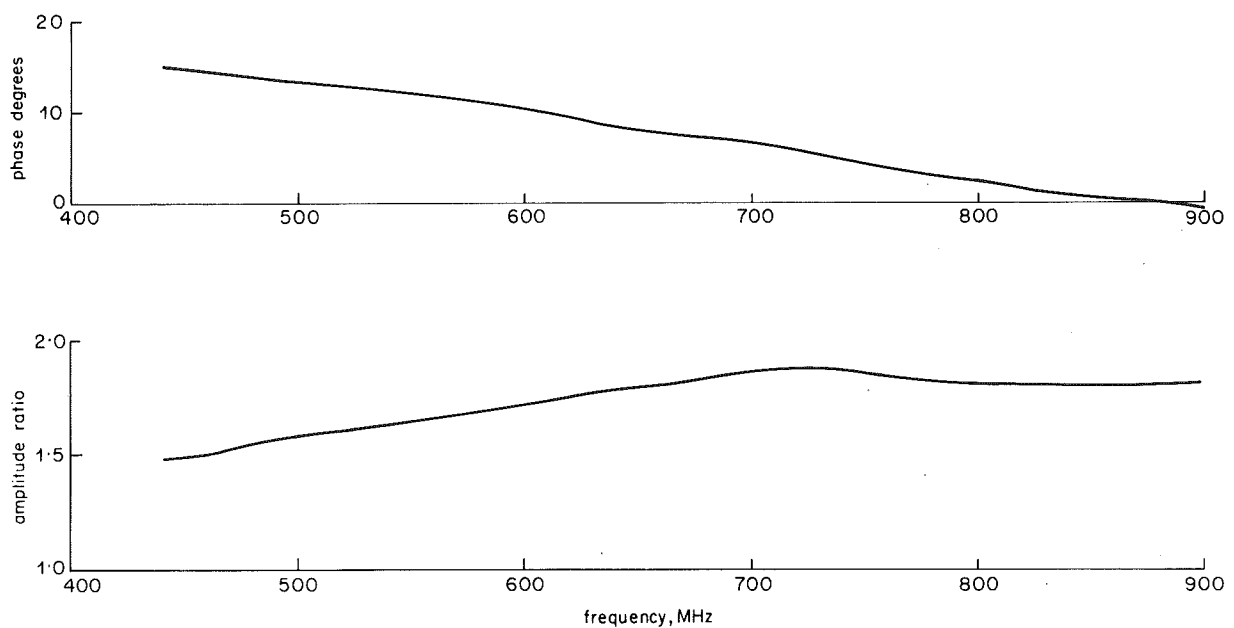


Fig. 4 - Current ratio of four-way transformer

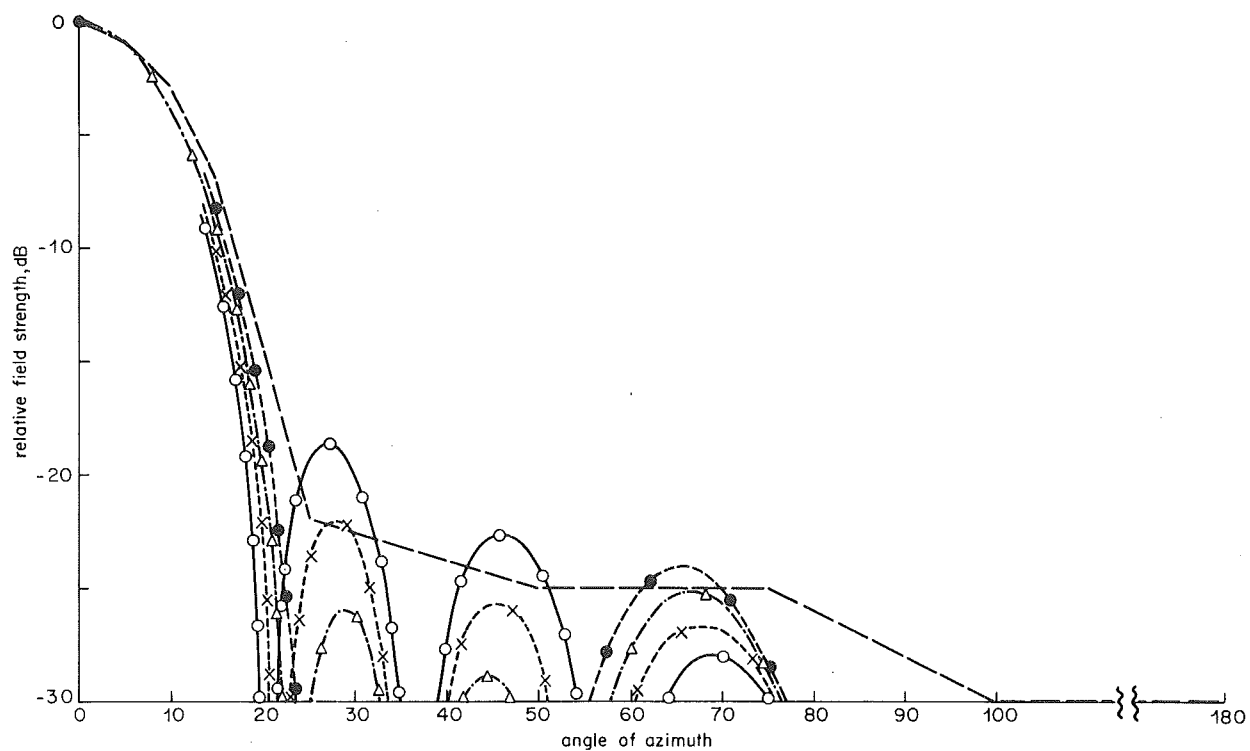


Fig. 5 - Effect of current ratio on side-lobe level

○ — 1 : 1.5 : 1.5 : 1      × — 1 : 1.75 : 1.75 : 1      △ — 1 : 2.0 : 2.0 : 1  
 ● — 1 : 2.25 : 2.25 : 1      — — — Directivity assumed in calculating co-channel interference

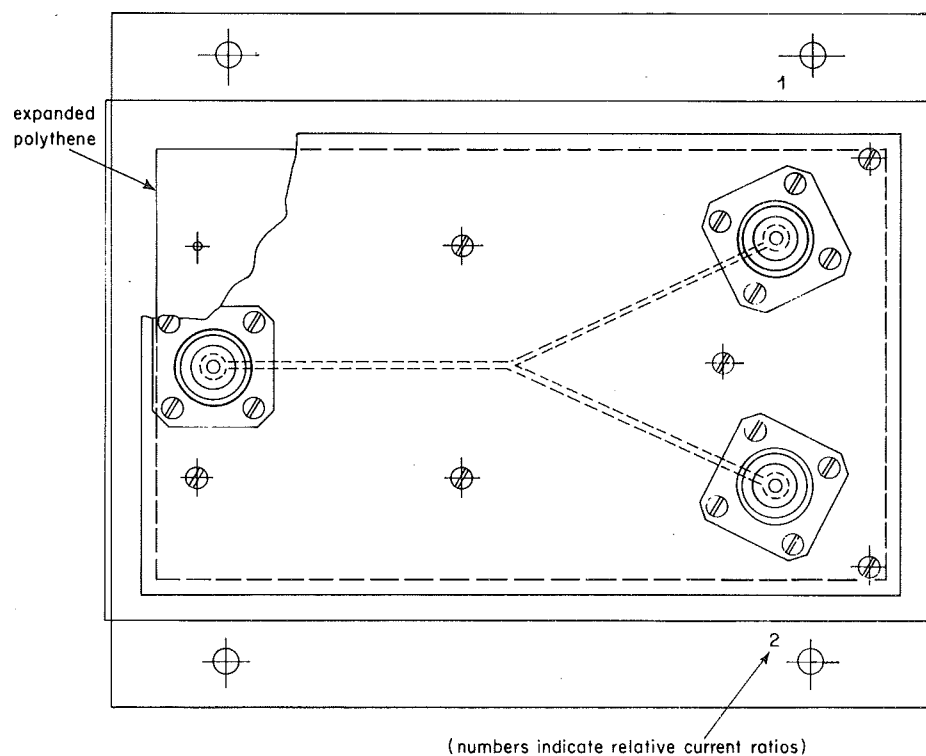
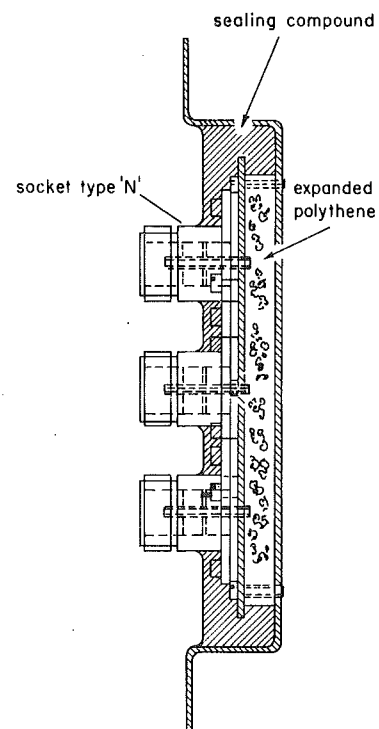


Fig. 6 - Layout of two-way transformers



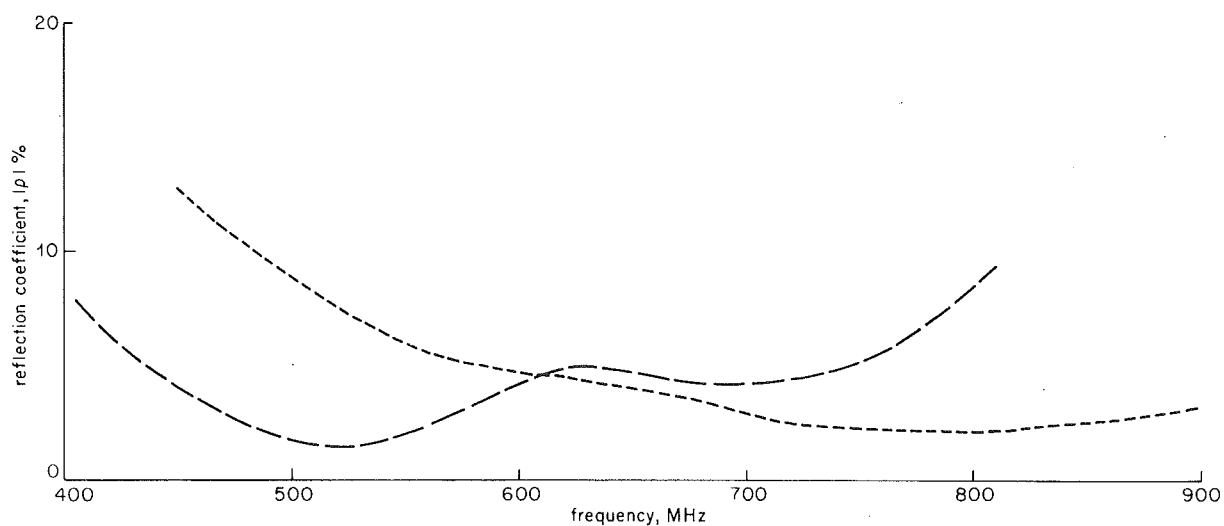


Fig. 7 - Reflection coefficient of two-way transformers

— Band IV Model      - - - - - Band V Model

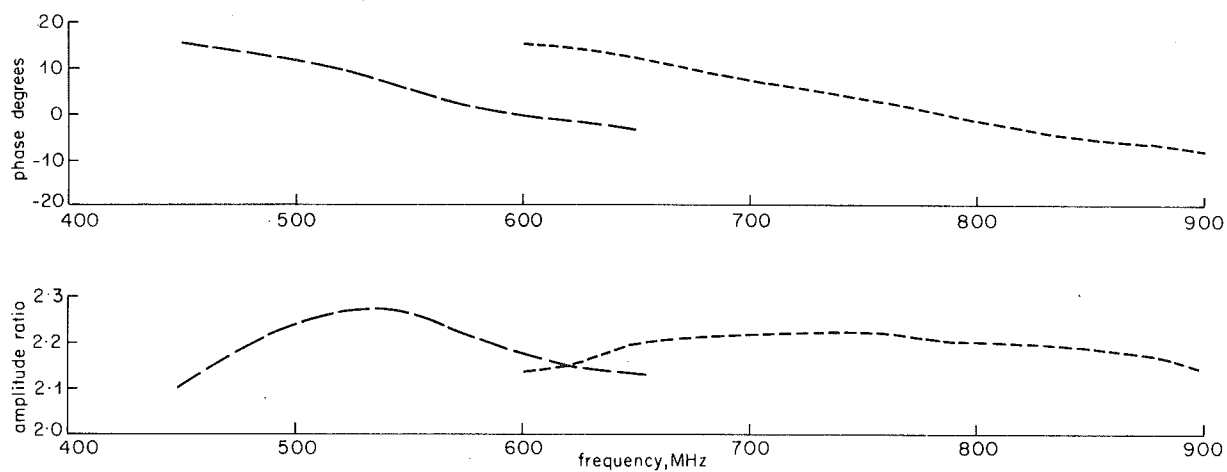


Fig. 8 - Output ratios of two-way transformers

— Band IV Model      - - - - - Band V Model

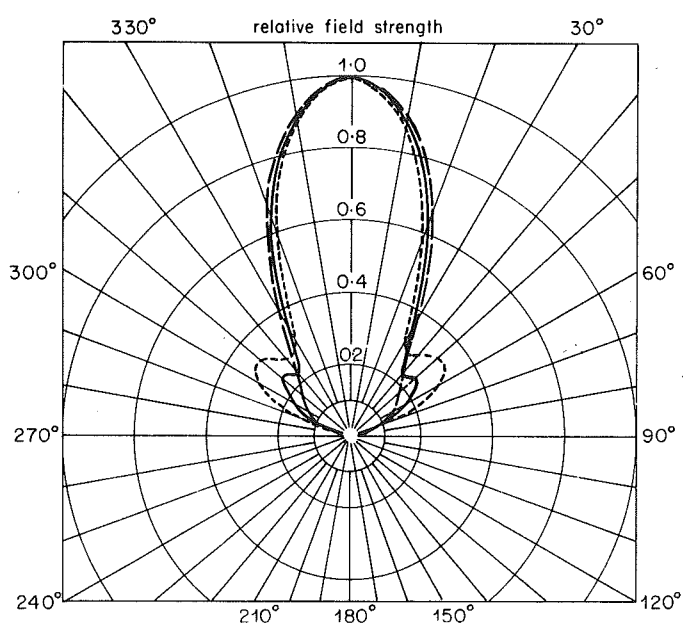


Fig. 9 - Horizontal radiation pattern of RBL aerial under emergency conditions

- - - - -  $0.9 f_0$       —  $f_0$ , mid-band frequency  
- - - - -  $1.1 f_0$

## 5. References

1. A u.h.f. trough aerial for re-broadcast reception. BBC Research Department Technical Memorandum No. RA-1019 February 1969.
2. Optimum parameters for a r.f. power-splitting network. BBC Research Department Report No. 1971/20.

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